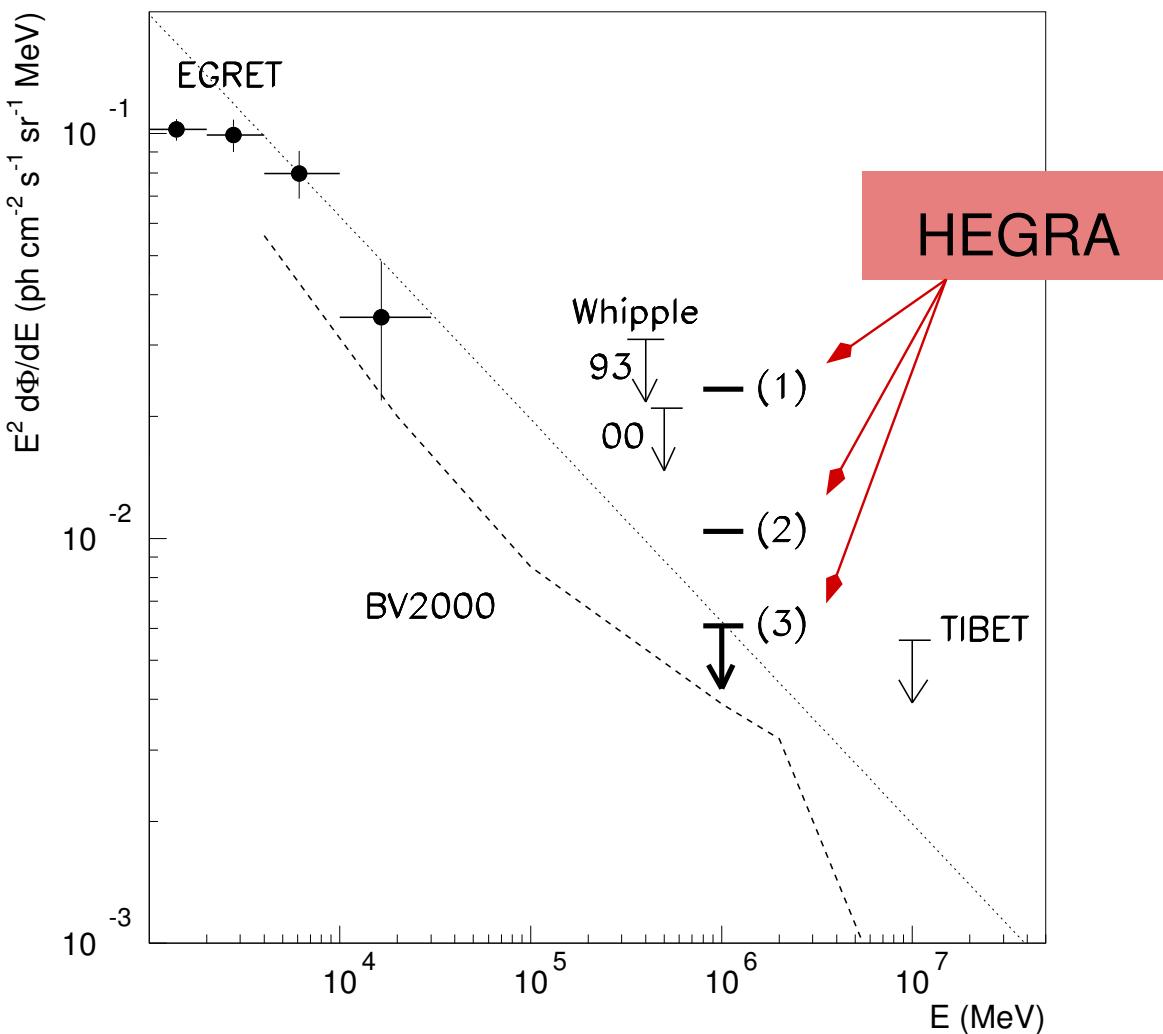


Diffuse emission at TeV energies – Observations with the HEGRA telescopes



HEGRA results:

Aharonian et al., A&A 375, 2001

Whipple (00) results:

LeBohec et al., ApJ 539, 2000

GCR & SCR modeling:

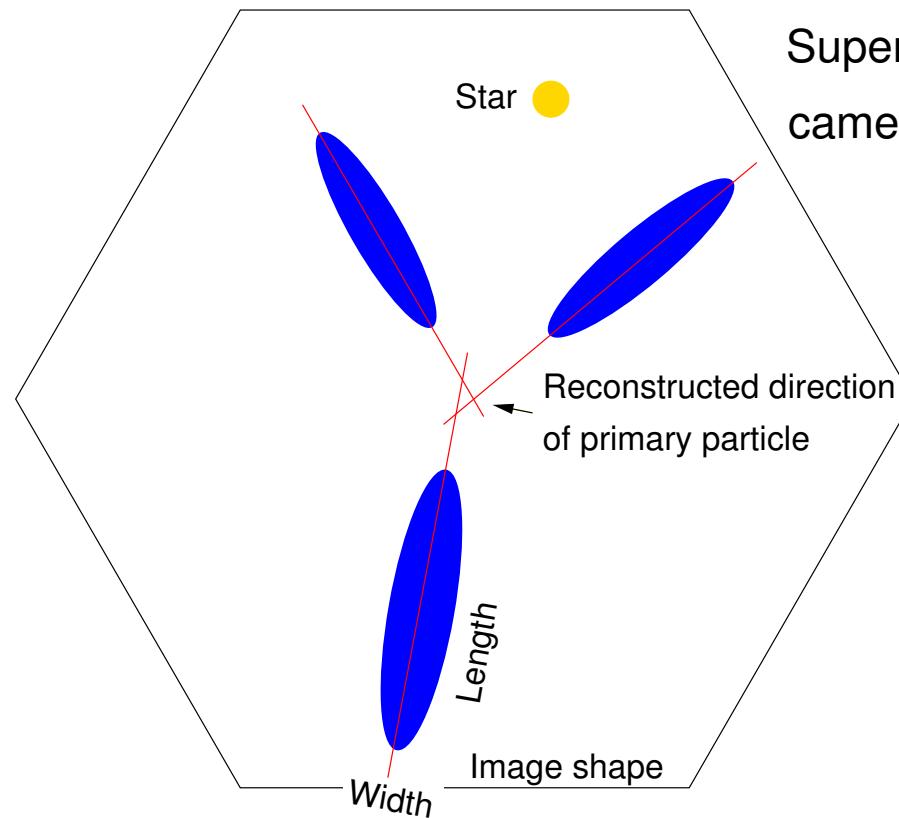
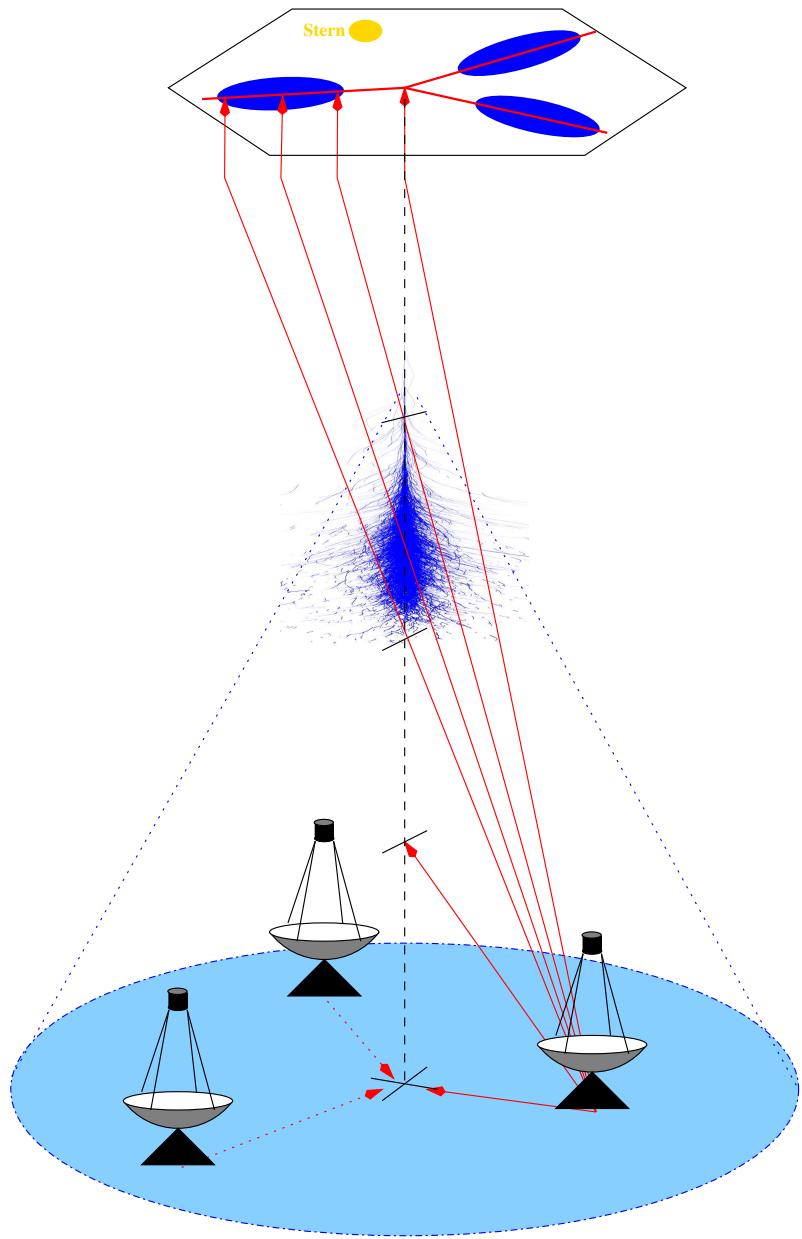
Berezhko & Völk, ApJ 540, 2000

Berezhko & Völk, ICRC 2003, p. 2433

Overview

- Imaging atmospheric Cherenkov technique
- The HEGRA IACT system
- Results from TeV measurements at Galactic longitude $l=40^\circ$
 - the HEGRA Galactic latitude scan
 - analysis techniques
- The impact of TeV measurements

The imaging atmospheric Cherenkov technique

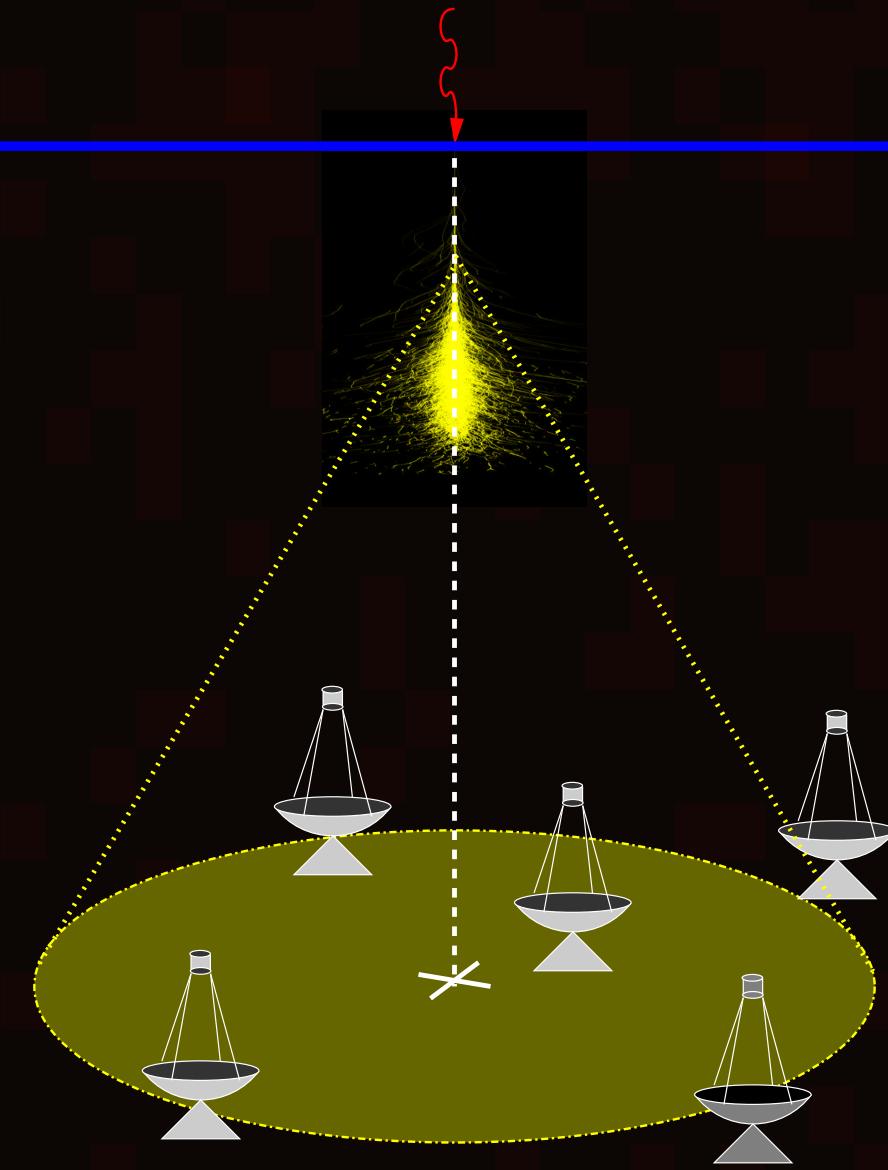


| | |
|-------------------|------------------|
| primary direction | $\sim 0.1^\circ$ |
| shower core | ~ 10 m |
| energy | 10% – 20% |

The HEGRA IACT system



system of 4 (later 5) 8.5 m^2 dishes
located on the Canary island La Palma
operational between 1997 and fall 2002



angular resolution: 0.1°
energy resolution: 10..20%
energy threshold: 500 GeV (zenith)

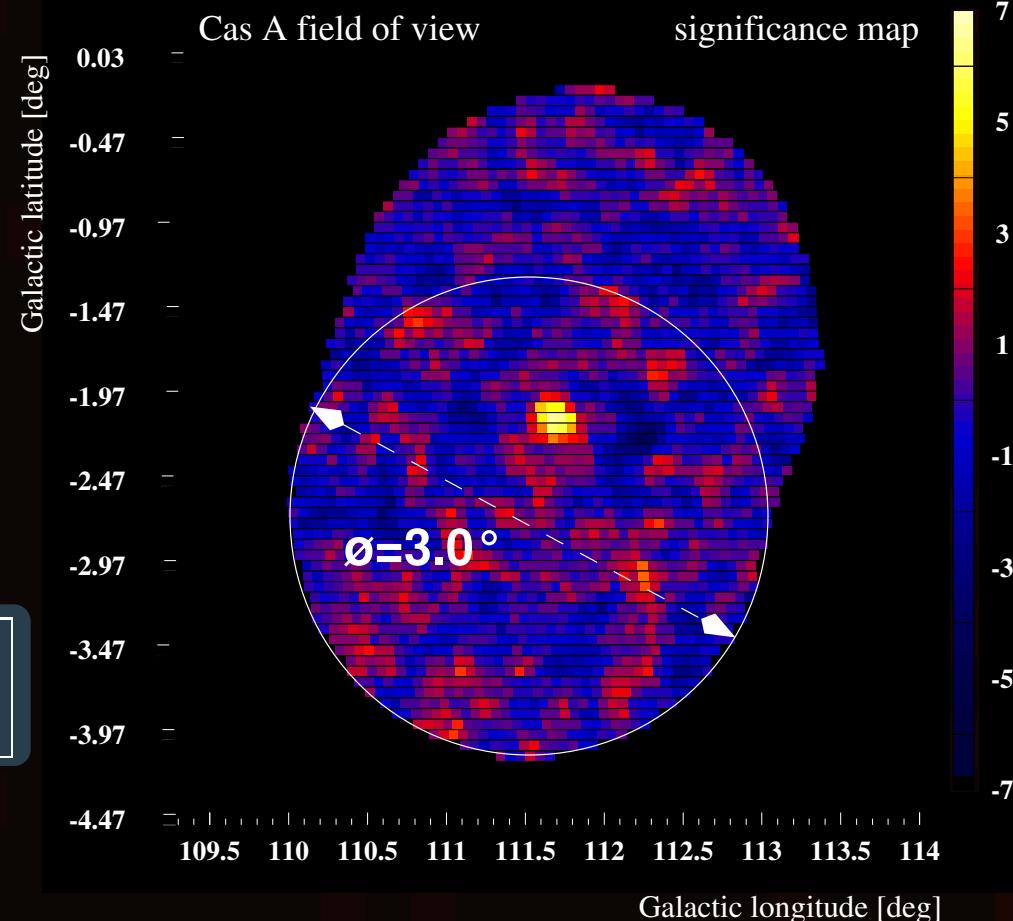
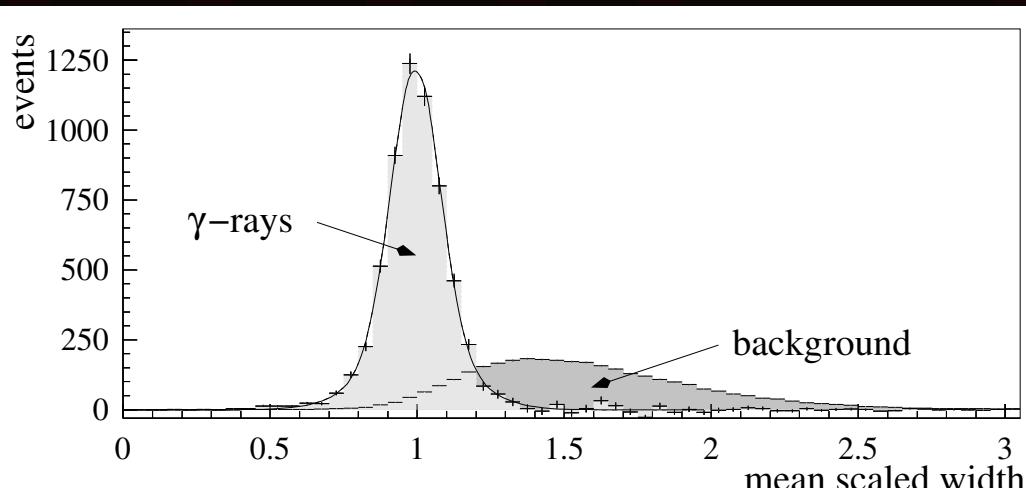
Properties of the HEGRA IACT system

| | | |
|--------------------|--|-----------------------|
| angular resolution | per event: | median = $0^\circ.09$ |
| field of view | homogeneous γ -acceptance: $\odot = 2^\circ$ $> 50\%$ of peak γ -acceptance: $\odot \simeq 4^\circ$ | |

point sources are well contained in FoV

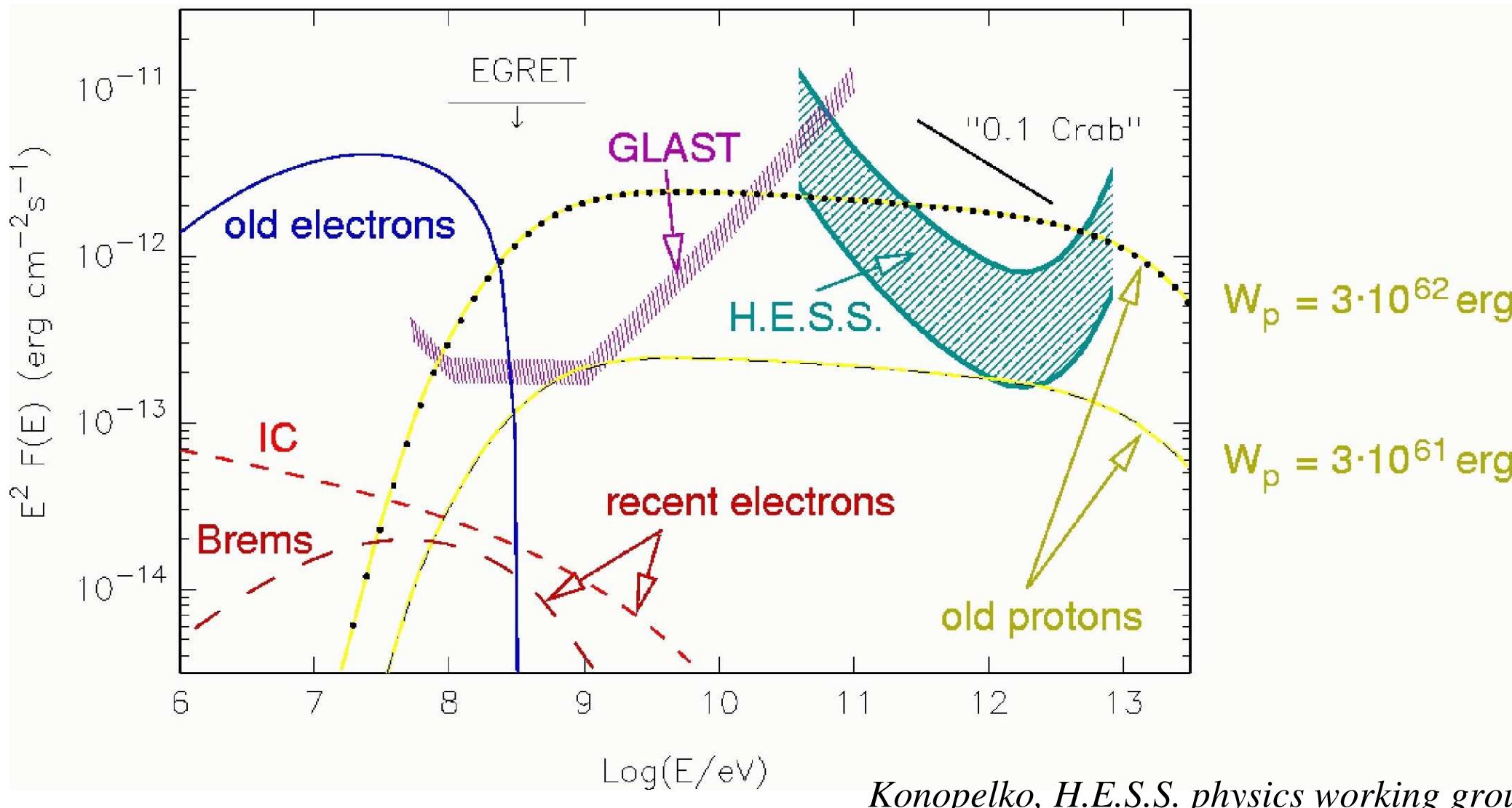
other parts of FoV can be used for background determination

| | | |
|------------------|-----------------------------------|---|
| flux sensitivity | quasi background-free, $t < 1$ h: | $0.3 \text{ Crab} \times (t/1 \text{ h})^{-1}$ |
| | background dominated, $t > 1$ h: | $0.03 \text{ Crab} \times (t/100 \text{ h})^{-1/2}$ |



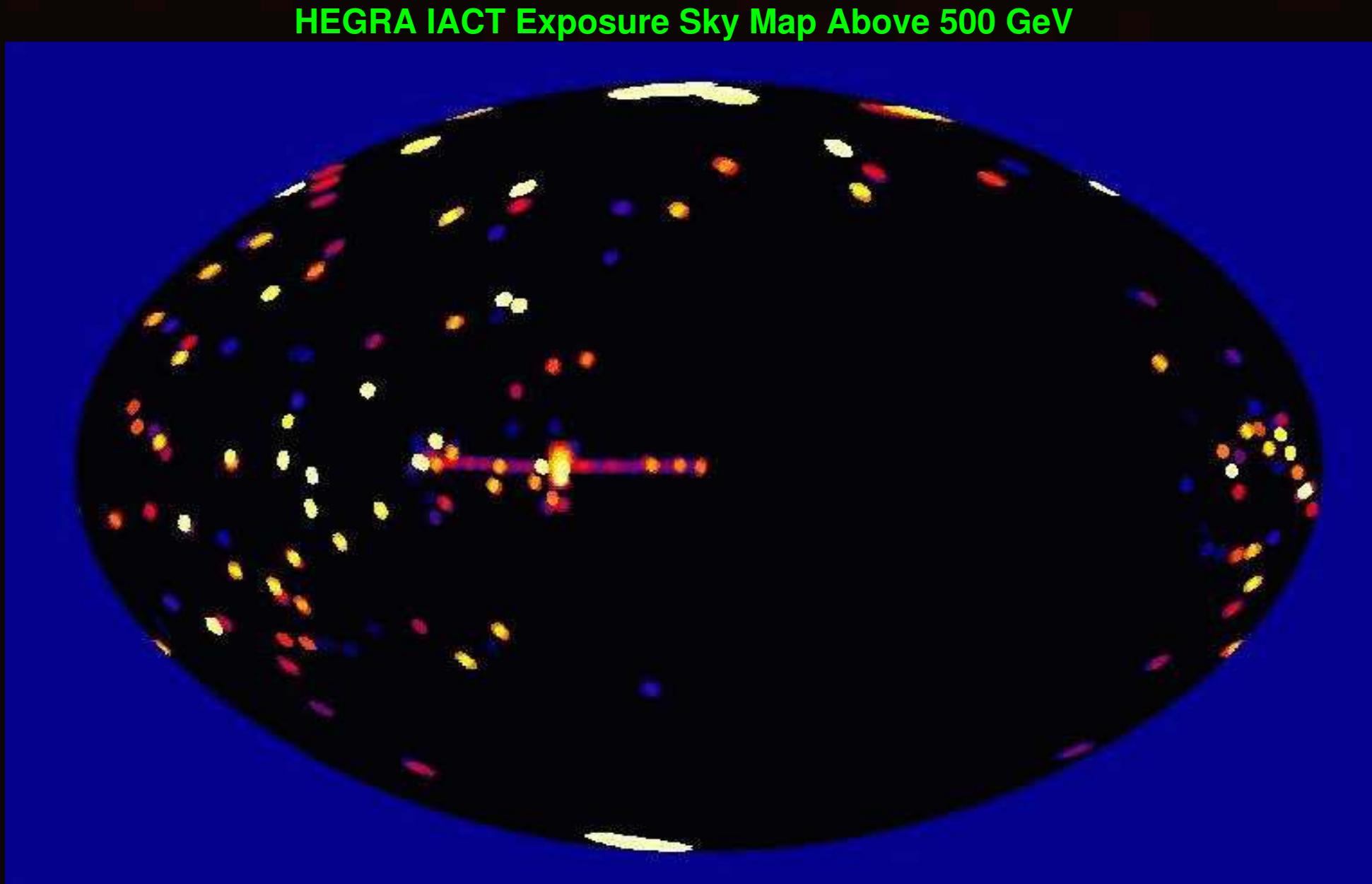
weak sources can only be detected
after strong background suppression

Sensitivity to point sources and extended sources

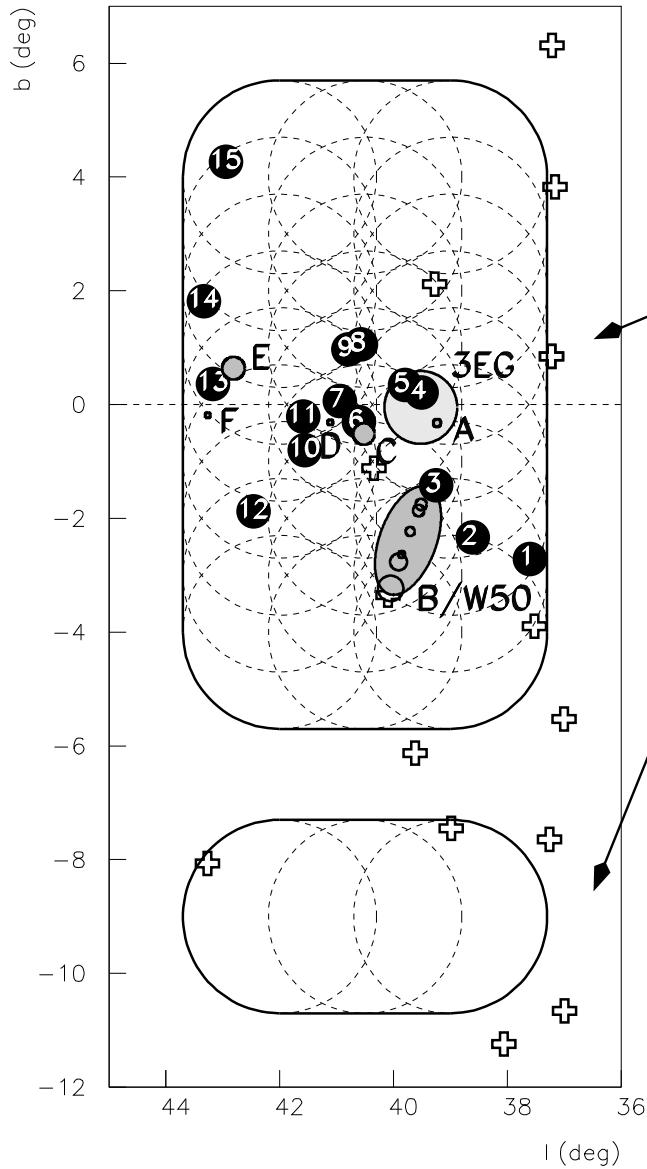


for TeV Cherenkov detectors: $\sim R_{\text{source}}$

The TeV gamma ray sky: HEGRA exposure time



The HEGRA Galactic latitude scan



HEGRA system:

41.7 hrs scan, zenith angle $\sim 30^\circ \rightarrow E_{\text{thr}} \sim 900 \text{ GeV}$

4.1 hrs @ control region

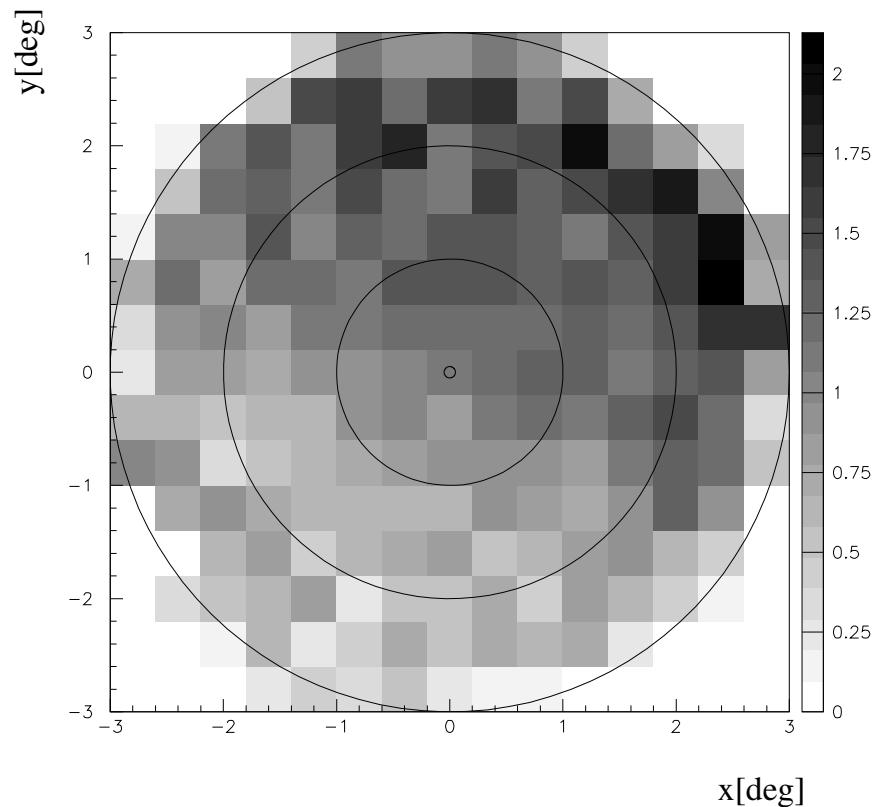
Whipple (00):

7.9 hrs on $b=0^\circ$, 7.9 hrs off data

(4.7/4.7 hrs @ 500 GeV, 3.3/3.3 hrs @ 700 GeV)

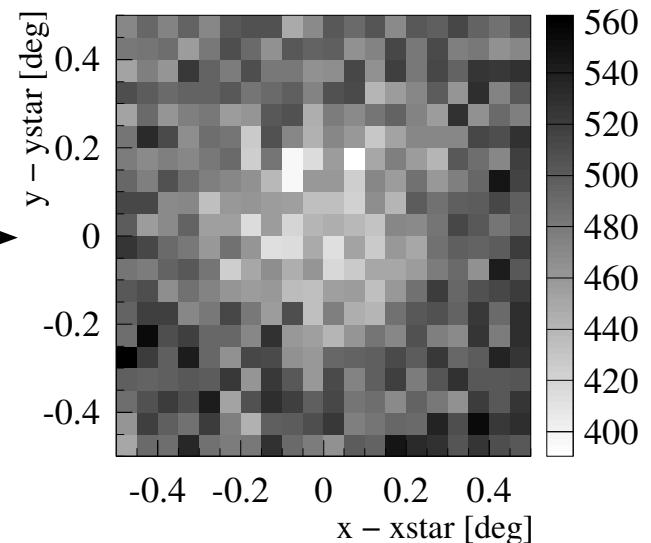
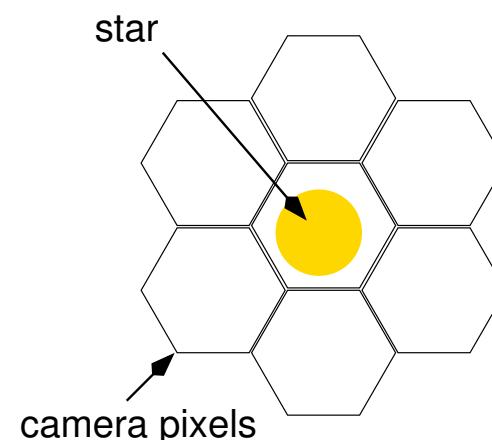
Acceptance calibration across the FoV with BG events

Whipple

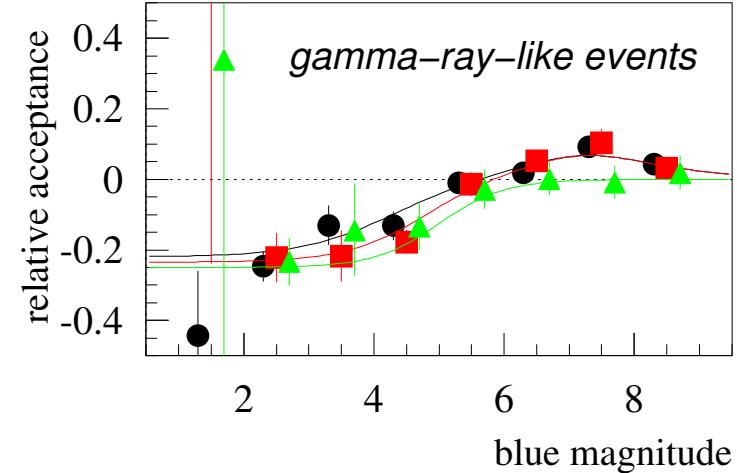


LeBohec et al., ApJ 539, 2000

HEGRA



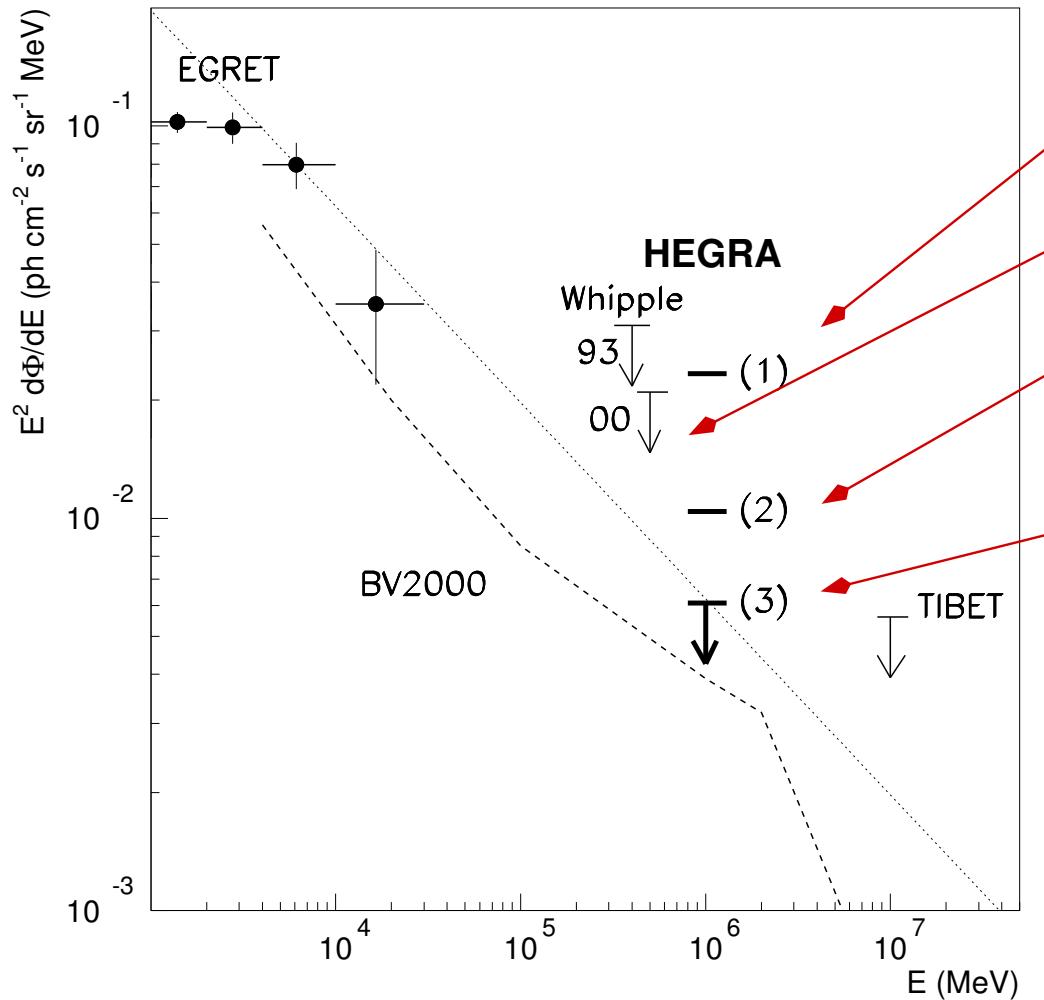
pixels with $DC > 3\mu A$
are set to 0
→
lack of events
from star position



Pühlhofer, ICRC 2003

TeV upper limits on the diffuse emission of the Galactic plane

different procedures:

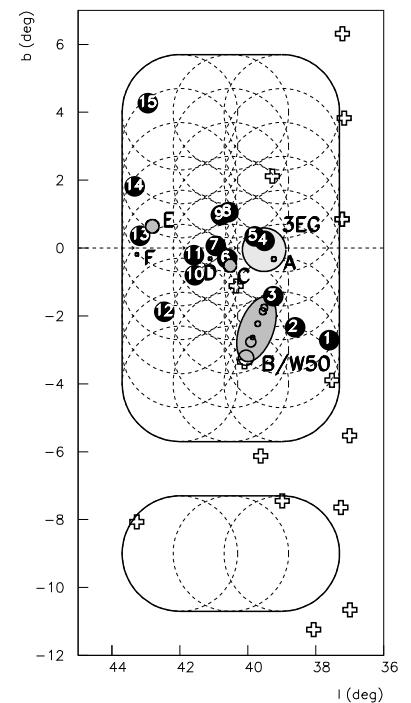


"background-free": very strong cuts

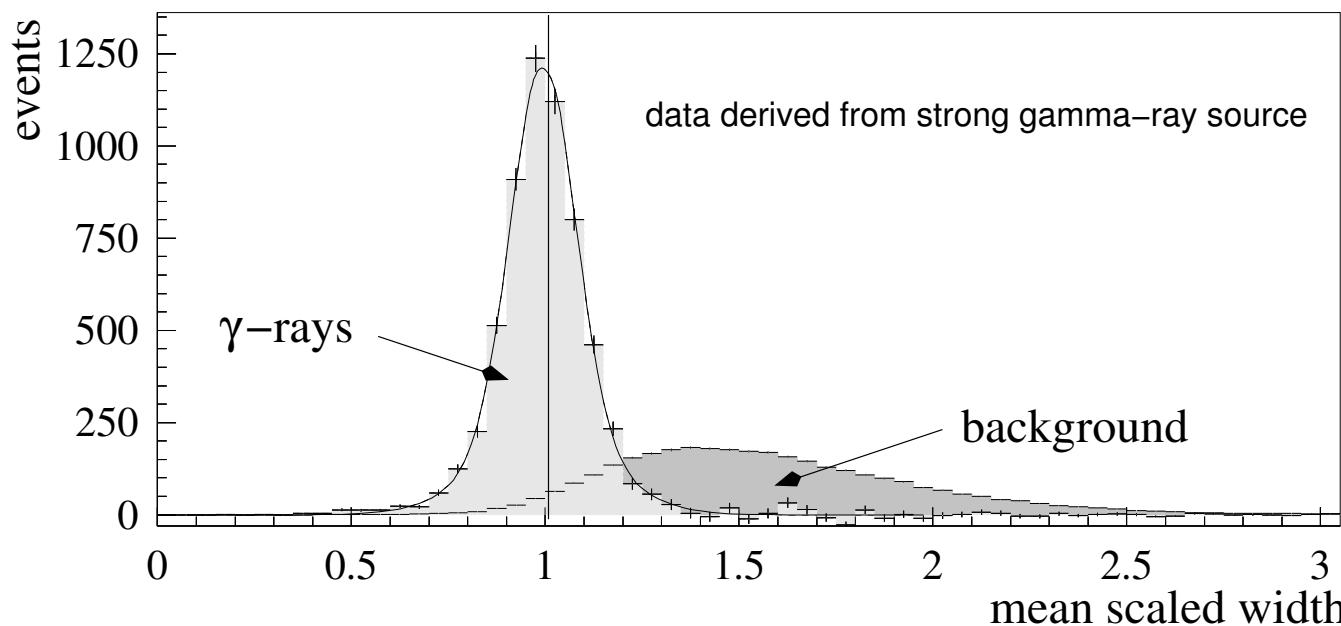
on – off, FoV acceptance \times GeV profile

on – off (small off sample)

assume GeV profile,
compare $|b| < 2^\circ$
with $|b| > 2^\circ$



HEGRA: Quasi—"background-free"



optimize signal/background: mean scaled width < 1.0

count all events after cuts in $|b| < 5^\circ$ as gamma-ray candidates

$$\frac{d\Phi}{dE}(E = 1 \text{ TeV}) < 23.4 \times 10^{-15} \text{ ph cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \text{ MeV}^{-1}$$

limit on:

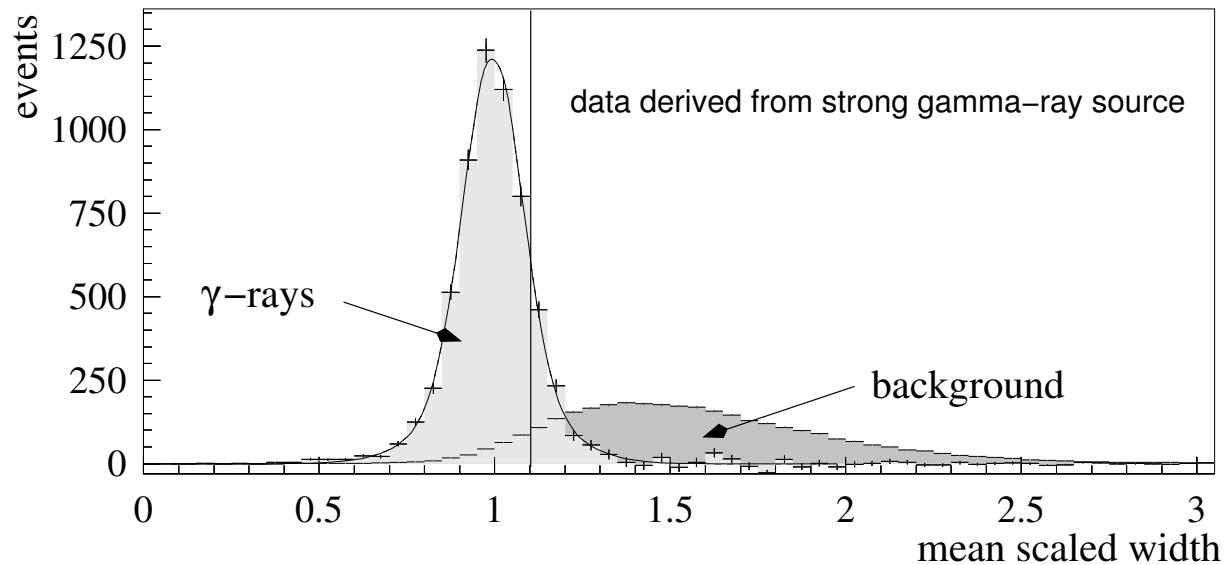
diffuse gamma-ray flux

diffuse electron flux

robust but least sensitive limit

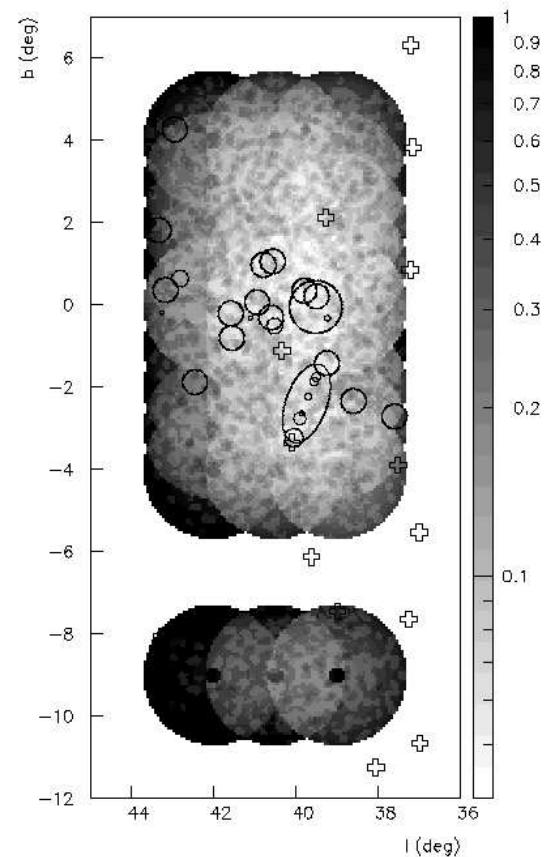
contains tail of the distribution of cosmic-ray nuclear showers

HEGRA: Background-subtracted: off counts from latitude <-6°



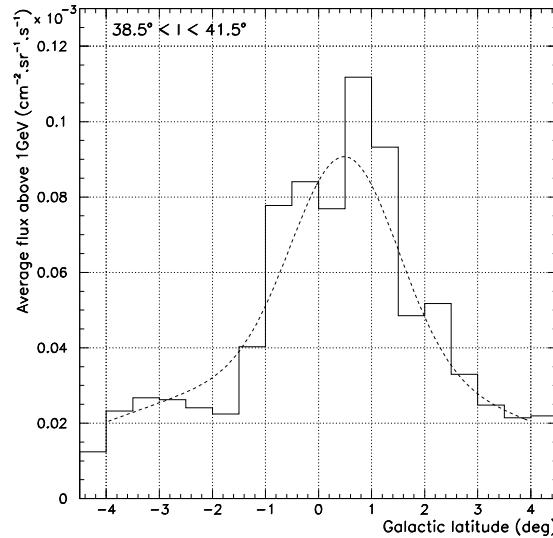
optimize signal/sqrt(background): mean scaled width < 1.1
count events after cuts and background subtraction
in $|b| < 5^\circ$ as gamma-ray candidates

$$\frac{d\Phi}{dE}(E = 1 \text{ TeV}) < 10.4 \times 10^{-15} \text{ ph cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \text{ MeV}^{-1}$$

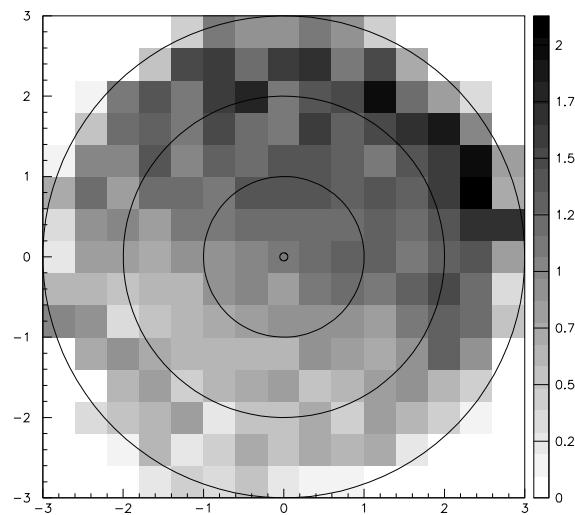


problem in HEGRA data sample: small off-exposure (4.1h)

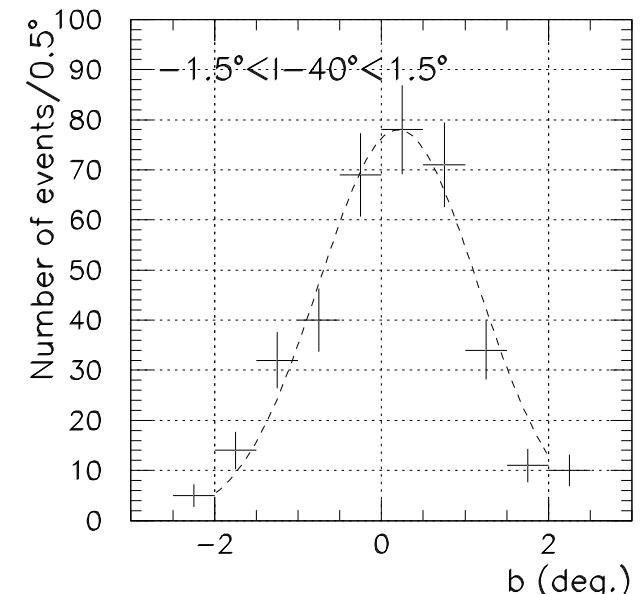
Whipple: On-Off, instrument acceptance x GeV profile



GeV latitude profile



\times gamma acceptance (projected) \rightarrow

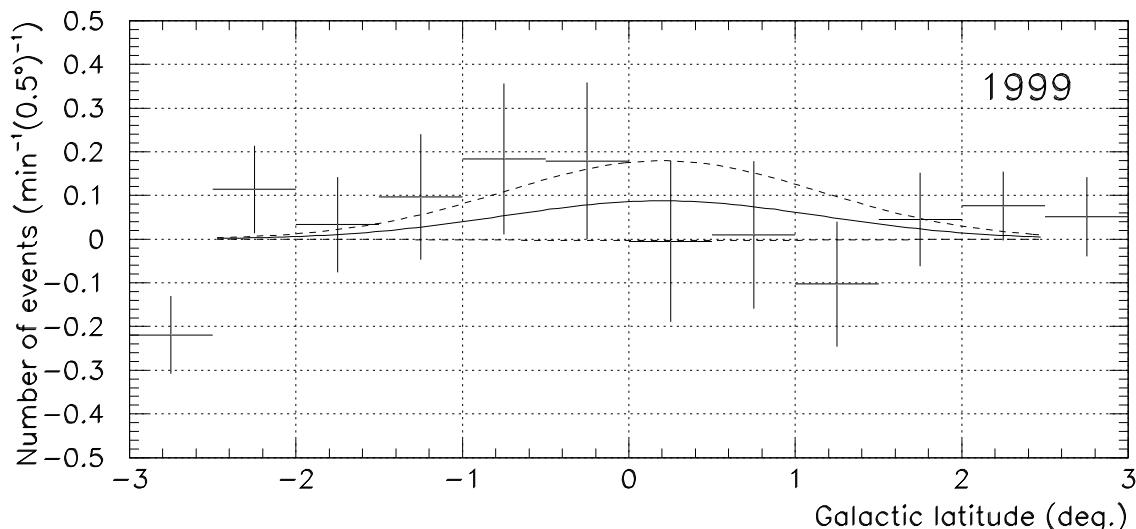


expected TeV profile

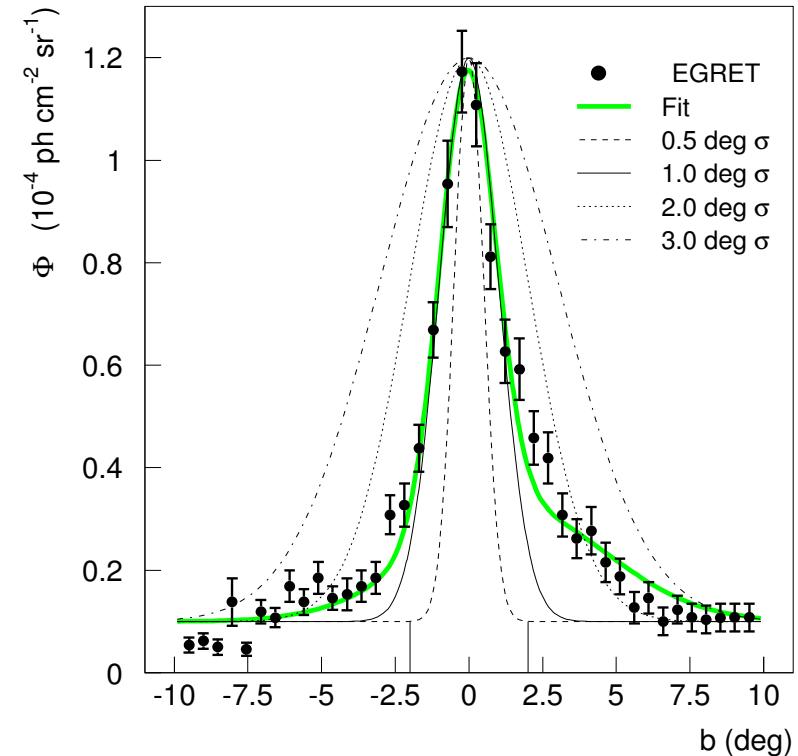
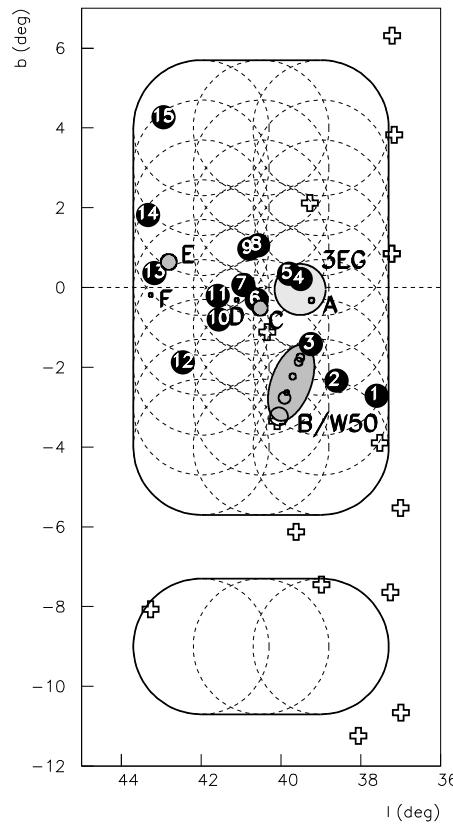
TeV data:

$$\Phi(E > 500 \text{ GeV}) < 3.0 \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

$$|b| < 2^\circ$$



HEGRA: on-off (compare $|b| < 2^\circ$ with $|b| > 2^\circ$), GeV profile



optimize signal/sqrt(background): mean scaled width < 1.1

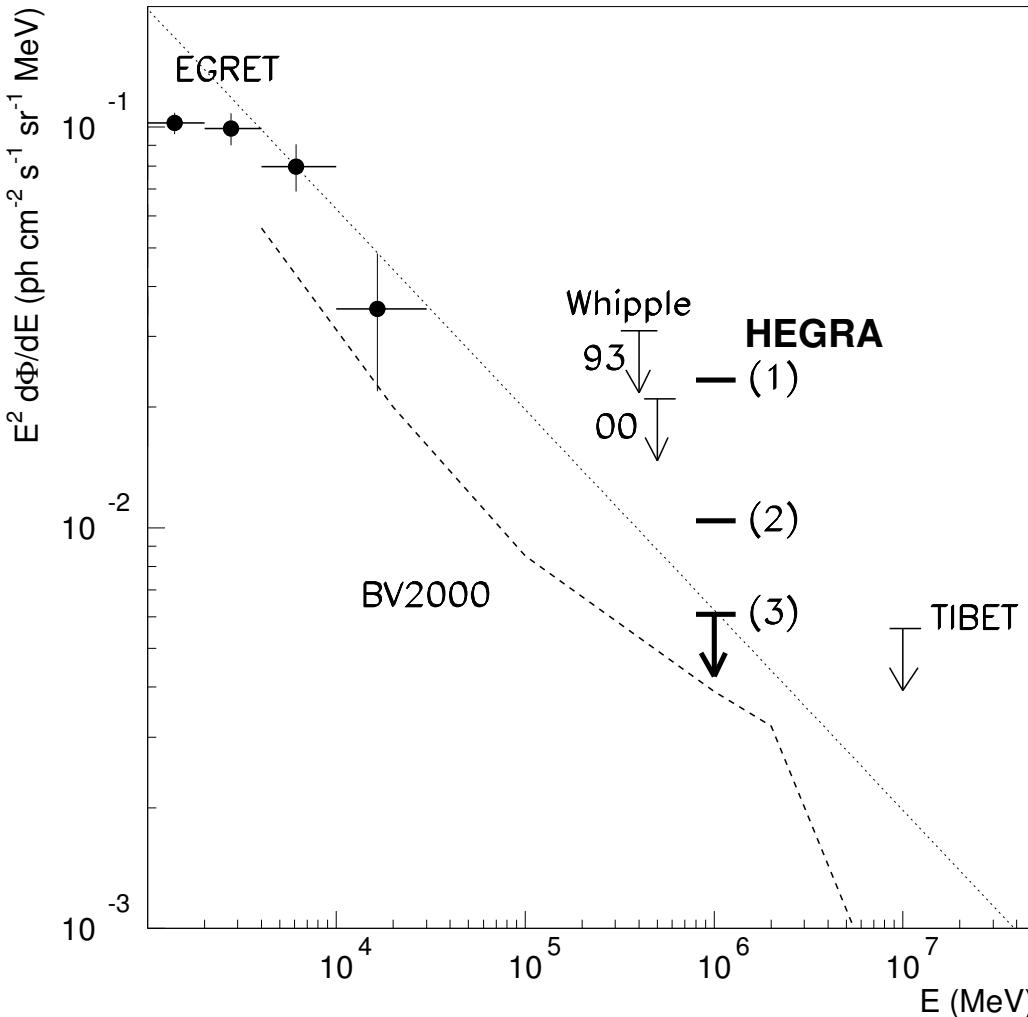
count events after cuts and background subtraction ($|b| > 2^\circ$)

in $|b| < 2^\circ$ as gamma-ray candidates

$$\frac{d\Phi}{dE}(E = 1 \text{ TeV}) < 6.1 \times 10^{-15} \text{ ph cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \text{ MeV}^{-1}$$

best limit, but higher degree of assumptions

Impact of TeV results



EGRET extrapolation:

Whipple (00):

$$\alpha < -2.31$$

HEGRA:

$$\alpha < -2.5$$

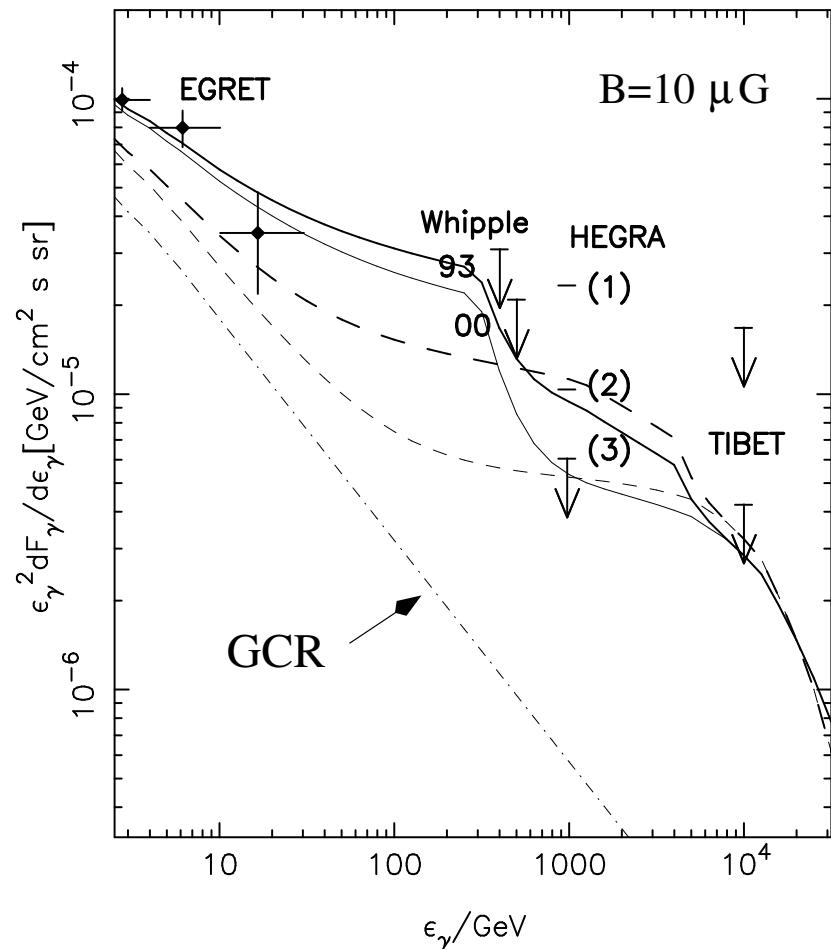
BV 2000:

contribution from source cosmic rays

The contribution from source cosmic rays (including IC)

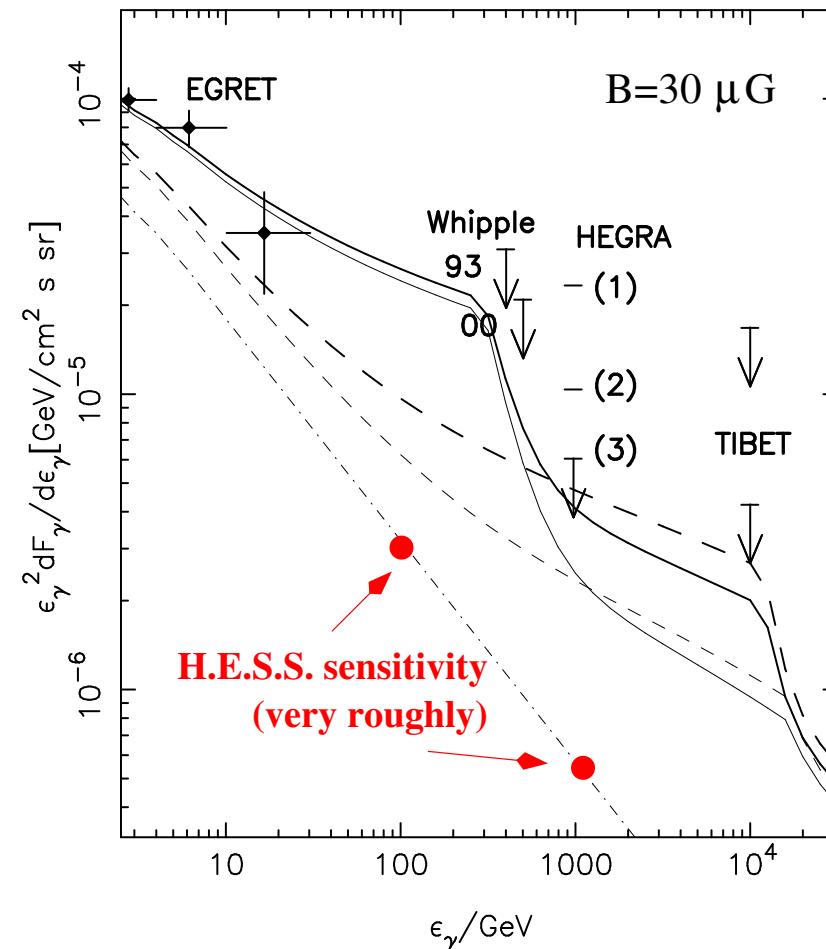
solid lines: 32% of SN energy into wind bubbles

Berezhko & Völk, ICRC 2003



B in SNR: $B=10 \mu\text{G}$: IC-dominated

HEGRA limit: o.k. if $T_{\text{SN}} = 2 \times 10^4$ years



$B=30 \mu\text{G}$: π° -dominated

o.k.

The H.E.S.S. Cherenkov Telescope System in Namibia

System of 4 12m diameter air–Cherenkov telescopes

120 m array spacing

15 m focal length, 5° field of view

~100 GeV threshold, centi–Crab sensitivity

Status:

2 tels running in stereo mode

3rd camera installed now

full system early 2004

